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13. ABSTRACT *(Maximum 200 words)*

A broad research program in optics was conducted that included the successful study of the following topics. Nonlinear effects in pulse propagation in fibers. The effects of gain saturation on self-phase modulation during the amplification of picosecond pulses in semiconductor lasers. The development of a theory for superfluorescent decay. Light emission from silicon and optical waveguiding in silicon wafers. Finally, the effects of substrate preparation on mass transport properties in glass waveguides was studied.

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Optics & Optoelectronic Systems

FINAL REPORT

Carlos Stroud

Joint Services Optics Program

Summary of Research Progress

July 1, 1991 - October 31, 1991

U. S. ARMY RESEARCH OFFICE

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The Institute of Optics
The University of Rochester
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PROGRESS REPORT

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"Delay-time statistics of cooperative emission in the presence jof homogeneous line broadening," K. Rzazewski, M. G. Raymer, and R. W. Boyd, Phys. Rev. A **39**, 5785 (1989).

"Correction of period motion artifacts along the slice selection axis in MRI," T. Mitsa, K. J. Parker, W. E. Smith, A. M. Tekalp, and J. Szumowski, IEEE Trans. Medical Imaging, Sept. 1990.

"Observation of fractional revivals in the evolution of a Rydberg atomic wave packet," J. A. Yeazell and C. R. Stroud, Jr., Phys. Rev A **43**, 5153 (1991).

"Wave packets in a semiconductor superlattice," M. L. Biermann and C. R. Stroud, Jr., Appl. Phys. Lett. **58**, 2279 (1991).

"Classical and quantum-mechanical dynamics of a quasiclassical state of the hydrogen atom," Z. D. Gaeta and C. R. Stroud, Jr., Phys. Rev. A **42**, 6308 (1990).

"Classical atoms and quantum mechanical wave packets," J. A. Yeazell and C. R. Stroud, Jr., Acta Phys. Pol. **A78**, 253 (1990).

"Observation of the collapse and revival of a Rydberg electronic wave packet," J. A. Yeazell, M. Mallalieu, and C. R. Stroud, Jr., Phys. Rev. Lett. **64**, 2007 (1990).

"Population trapping in short-pulse laser ionization," J. Parker and C. R. Stroud, Jr, Phys. Rev. A **41**, 1602 (1990).

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"Electroluminescence from sulfur impurties in a p-n junction formed in epitaxial silicon," P. L. Bradfield, T. G. Brown, and D. G. Hall, Appl. Phys. Lett. **55**, 100 (1989).

"Radiative decay of excitons bound to chalcogen-related isoelectronic impurity complexes in silicon," P. L. Bradfield, T. G. Brown, and D. G. Hall, Phys. Rev. B**38**, 3533 (1988).

"Concentration dependence of optical emission from sulfur-doped crystalline silicon," T. G. Brown, P. L. Bradfield, and D. G. Hall, Appl. Phys. Lett. **51**, 1585 (1987).

"Generation and statistical properties of optical dead-time effects," D. J. Cho and G. M. Morris, J. Mod. Opt. **35**, 667 (1988).

"Local dead-time effects in microchannel-plate imaging detectors," D. J. Cho and G. M. Morris, Proc. SPIE **976**, 172 (1988).

8. SCIENTIFIC PERSONNEL SUPPORTED BY THIS PROJECT AND DEGREES AWARDED DURING THIS REPORTING PERIOD:

Faculty

Govind P. Agrawal
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Thomas G. Brown
Dennis G. Hall
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G. Michael Morris
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Jonathan Parker
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Mark L. Biermann, PhD
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Wayne Robert Tomkin, PhD
Doo Jin Cho, PhD
Stephen F. Chakmakjian, PhD
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9. BRIEF OUTLINE OF RESEARCH FINDINGS:

A. **Nonlinear effects in optical fibers** Govind Agrawal carried out a detailed investigation of the spectral and temporal changes experienced by weak probe pulses as a result of cross-phase-modulation interaction with pump pulses. The probe pulses are predicted to be compressed by a factor of more than 10 when the initial delay between the pump and probe pulses is suitably optimized.

B. **Amplification of weak picosecond pulses using semiconductor laser amplifiers.** Govind Agrawal found that gain saturation invariably leads to intensity-dependent changes in the refractive index which are responsible for self-phase modulation. it appears that semiconductor-laser amplifiers can be used for simultaneous compression and amplification of weak picosecond pulses.

C. **Delay time statistics of cooperative emission in the presence of homogeneous line broadening** Robert Boyd and Michael Raymer developed a theoretical model for superfluorescent decay and find that as the collisional dephasing rate is increased, the mean delay time increases and the distribution broadens. The theory fits well the data from their earlier experiment.

D. **Silicon-based light emitting diode** Brown and Hall examined two types of silicon-on-insulator structures that represent the state of the art at the present time. The first is SIMOX (Separation by IMplanted OXygen) technology, in which a a buried layer of silicon dioxide is created a few tenths of a micron below the surface of a silicon wave by means of ion-implantation and thermal post-processing. They demonstrated optical waveguiding in such wafers and are working to reduce interface roughness that seems to be producing excessively high attenuation. The second such structure is known as BESOI (Bond and Etchback Silicon on Insulator) technology. This material is prepared by bonding two oxidized silicon substrates together, then etching one of the wafers down to a thin layer. Fabrication is underway of these structures.

E. **Effect of substrate preparation on mass transport properties in glass waveguides** Susan Houde-Walter has identified a glass/salt pair of materials with ideal properties for fabrication of waveguides by ion diffusion. The glass has been customed melted and formed. A fluidized bath and temperature control have been assembled and tested, and initial diffusion experiments have begun with good results.

F. **Dead-time effects in photon counters** Michael Morris carried out experiments studying the effects of dead time on two-dimensional microchannel plate photon counting devices and determined the effect of this phenomenon on quantum limited imaging.

G. **Coherent electronic wave packets in semiconductor microstructures** Carlos Stroud developed a computer code to model wave packet formation in semiconductor quantum-well superlattices. The code was based on the $k \cdot p$ model of Malliot. It showed that picosecond laser excitation can efficiently excite spatially localized wave packets that oscillate back and forth harmonically many times before dispersing. Work is continuing to apply this to the development of teraHertz oscillators.